# National Electric Group Review

VOL.2 NUMBER 2 JULY 1965

SOUVENIR ISSUE

# BENMORE-COOK STRAIT PROJECT

*On behalf of myself, the Directors, Management and Staff, I offer our congratulations to all concerned with the gigantic and outstanding Benmore-Cook Strait project.*

*Having been associated in many ways with this project, we feel that it is fitting that we devote this entire issue of the "National Electric Group Review" to the Benmore-Cook Strait project. It therefore gives me great pleasure to present this issue to you with our compliments and to wish you pleasant and rewarding reading.*

Managing Director,
National Electric Group

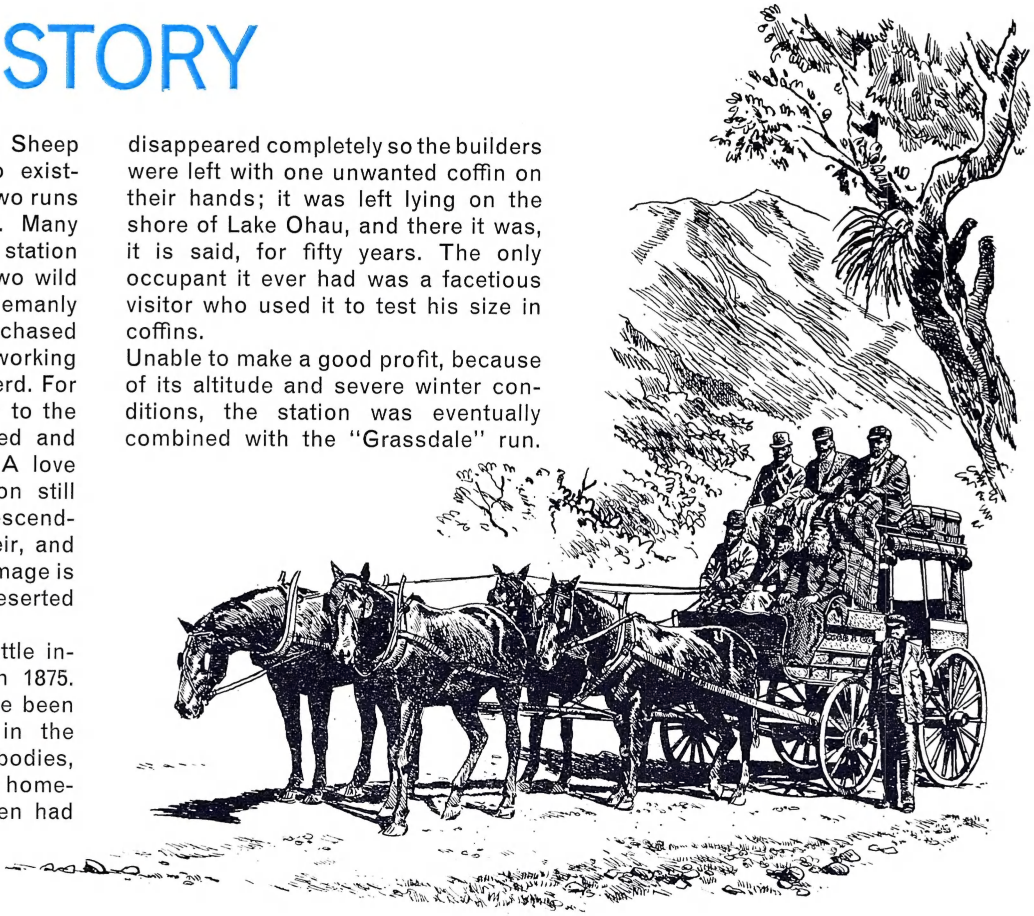
*We thank the following for their generous and courteous assistance . . . New Zealand Electricity Department, Ministry of Works, Otago Daily Times Newspaper, Otematata Welfare Association, Tourist and Publicity Department (Photographic Department), and the many others involved.*

# EARLY HISTORY

One of the first Canterbury Sheep Stations, Benmore came into existence in 1857 and consisted of two runs of nearly 10,000 acres in all. Many people held control of the station through the years, including two wild young men described as "Gentlemanly Ne'er-do-wells", until it was purchased by one Matthew Weir, a hard-working and far-seeing Scottish shepherd. For many years the Weirs held on to the station, but eventually departed and went to live in Christchurch. A love for the lonely Benmore Station still lives within the hearts of the descendants of Matthew and Mary Weir, and for this reason an annual pilgrimage is made to the ruins of the deserted homestead.

A curious story is told of a little incident that happened there in 1875. Two men were believed to have been missing and perished, and, in the expectation of finding both the bodies, two coffins were made at the homestead. However, one of the men had disappeared completely so the builders were left with one unwanted coffin on their hands; it was left lying on the shore of Lake Ohau, and there it was, it is said, for fifty years. The only occupant it ever had was a facetious visitor who used it to test his size in coffins.

Unable to make a good profit, because of its altitude and severe winter conditions, the station was eventually combined with the "Grassdale" run.



# BRIEF HISTORICAL NOTES

Prior to 1945 the idea of a power station at Benmore was discussed and it was decided to go ahead with preliminary investigations.

**1946** Access road started to the proposed site at Black Jack's Point. (Black Jack's point took its name from one "Black Jack" McCulloch who was a boundry keeper in the 1860's for the Benmore Station).

**1947 to 1949** Access road finished; investigations started; project now became known as the Benmore Project.

**1950** Seismic survey carried out on the river terraces. Stripping of the talus and exploratory drilling and tunnelling carried out. Telephone line to the works provided.

**1951 to 1952** Work continued slowly due to prevailing shortage of labour.

**1953 to 1955** Field work resumed. Grouting tests done to determine the permeability of the site. Report prepared.

**1956** Some doubts, so further investigations carried out on other possible dam sites.

*Looking upstream from the Otematata township.*

**1957** Government approval given for a power station to be built on the site. Design studies made for both concrete and earth dams. A scheme for an earth dam using locally available materials accepted.

**1958** Overburden stripped where the diversion culverts are to go.

**1959** Target set for the first power to be generated — 1965. Contract let for the production of the concrete aggregate. Otematata township started . . . accommodation, Post Office, school, Doctor's surgery, social hall and churches transported from Roxburgh. New buildings started included a block of 13 shops, Police Station and dental clinic. Four million gallon reservoir for domestic water provided.

**1960** Designs for the dam and spillway finished. A maternity hospital of 8 beds and a youth hall and gymnasium built at Otematata.

**1961** Diversion culverts completed, requiring 95,000 cubic yards of concrete, and the diversion of the Waitaki River accomplished. After the letting of the contract for the turbines and generators, a start made on the structural design of the power house.

**1962** Project now becoming known as a mecca for sightseers. More than 40% of the required material for the dam already in place. Other installation work well underway.

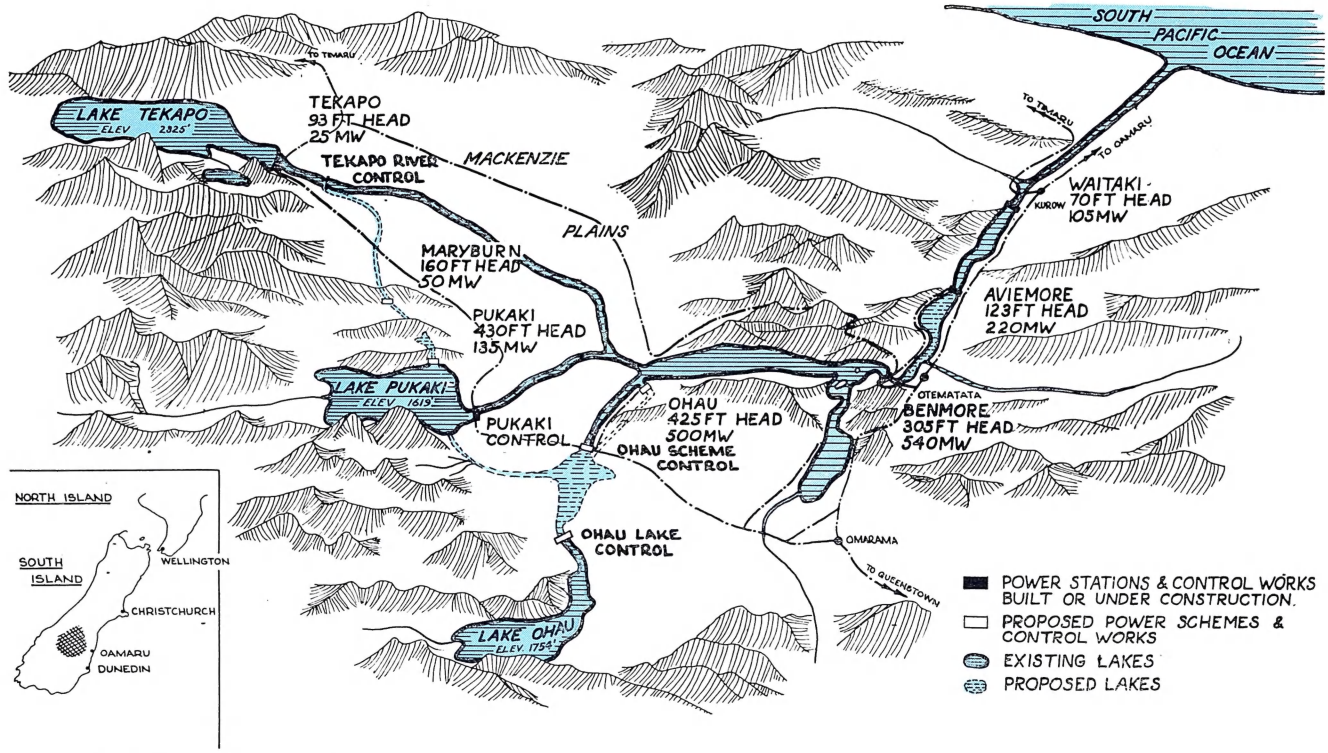
**1963** 1,240 men now employed on the project. Schedules being maintained with over 160 heavy earth moving, etc. machines in operation. 75% of the dam now placed. Construction of the control and office blocks and valve house underway. First turbine ready for hydraulic testing. Penstock sections being installed.

**1964** Manpower reached maximum of 1,470. Earth work of the dam approached completion. 85% of the major structural concrete in the power house completed. The generators for the first two machines installed. The permanent village now under construction, and the area to be flooded by Lake Benmore being cleared of trees and shrubs.

**1965 April:** The lake completed and now a cover for a forgotten valley. Power flowing and tests completed.

**May 15th:** Inauguration ceremony at Benmore.

*Access roads on the site.*




*Proposed Waitaki Basin development.*

# BENMORE

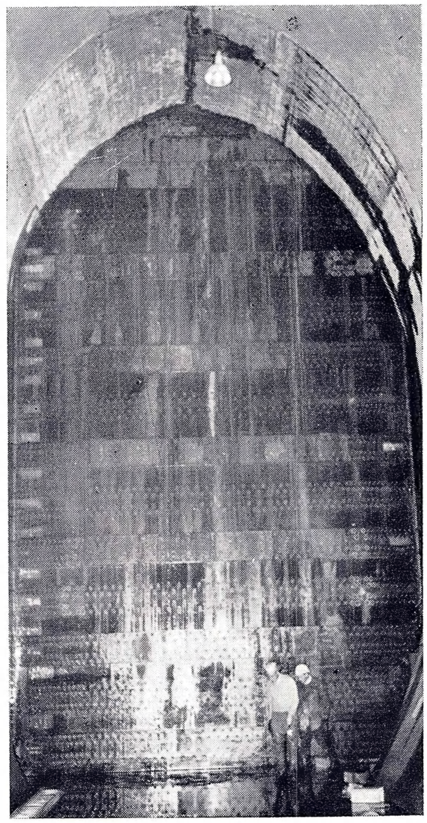
The proposed chain of stations envisaged for the Waitaki Basin could have a projected total capacity exceeding $1\frac{1}{2}$ million KW. Benmore, with its ultimate capacity of 540,000KW, will not only be the largest of the Waitaki Basin stations, but also the largest power station in New Zealand. The dam, 20 miles from Kurow, the nearest railhead, is reached by the main highway from Oamaru and has behind it New Zealand's largest artificial lake.

When the Benmore-Cook Strait Scheme was approved in 1957, the first major project to be undertaken was the diversion of the Waitaki River. This was begun in 1958 with excavations of a trench in the left bank of the river. The concrete diversion culverts, now inside the base of the dam, were constructed in this trench and consisted of two arched culverts 1,440 feet long, each 41 feet high by 25 feet wide and capable together of carrying almost six times the river's normal flow. Near the upstream end, concrete towers rising from the culvert floor contained the two 155-ton steel gates required to close the culvert when the lake was to be filled.

The Waitaki River was diverted into the culverts on 5th August 1960 and continued to flow over this man-made river-bed until the culvert gates were lowered on November 30th, 1964, allowing the lake to begin filling. Permanent sealing of the culverts was done by means of concrete plugs.

No water then passed downstream until the level of the sluice gates was reached on December 12th. Thereafter, some water was released to refill Lake Waitaki and replenish downstream irrigation and water supply services. Whilst Lake Benmore was in the process of being created, Lake Waitaki was used solely for water control, no electricity being generated there. On December 29th, Benmore Lake reached the spillway gates level and the sluices were closed. The spillway was then used to supply the downstream water. Working lake level, 1179.5 feet above sea level, was reached on January 14th, 1965 enabling the first tests to begin.

The Dam itself, which took only four years to complete, has a crest length of 2,700 feet, with a base width of 1,600 feet and a crest width of 36 feet. It reaches a height of 360 feet, and



*Diversion culvert and gate.*

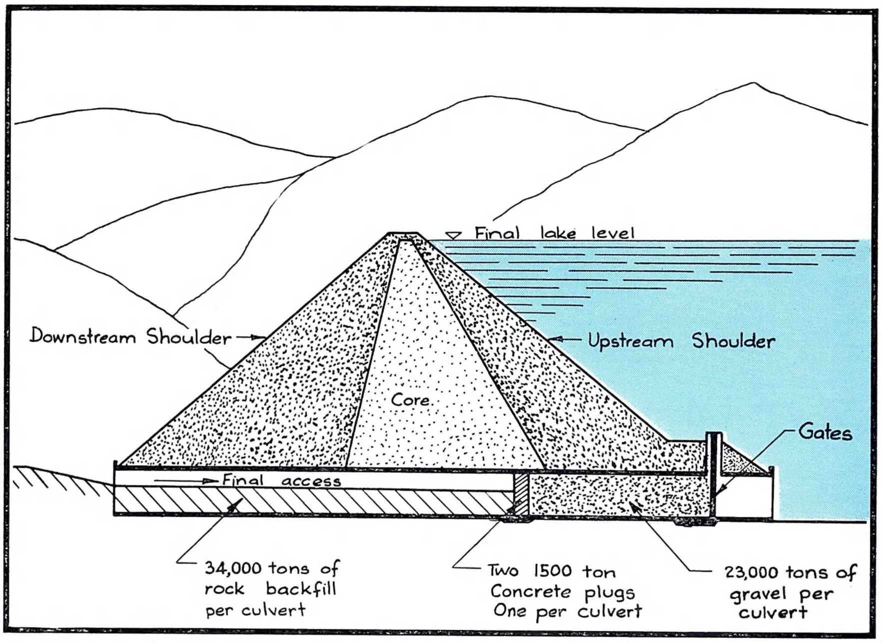
*Completed earth dam just prior to lake filling.*

across the crest a road has been built. The dam contains nearly 16 million cubic yards of earth and rock fill, which involved the cartage and compaction of 30 million tons of material.

To give some indication of the earth-moving capacity of modern machines, it would take 1000 men, each with a large wheelbarrow, working 8 hours a day for 365 days a year, 22 years to shift all the earth, etc. involved.

When the lake was filled and water was flowing down the penstocks the testing of turbines and generators began. The first test transmission from Benmore to Haywards was made on February 1st, 1965 using electricity from the South Island Grid.

At the foot of the Penstocks stand the all-important buildings housing the machinery necessary for the production and transforming of the power. There are two large outdoor stations, one AC to transmit power to the South Island grid, the other DC where the generated AC power is converted for transmission to the North Island. The power station is connected with the South Island network so that its power can, if desired, be used in the South, or power from the other South Island stations can be transmitted to the North, after conversion to DC.




*A cross section view of the dam.*

To move the heavy equipment for maintenance and repairs there are two 120 ton cranes in the power-house. Some of the equipment involved includes six main 125,000 bhp turbines from Canada, each weighing 300 tons, and two auxiliary turbines of 3,500 bhp from Germany. Each main turbine is connected to a 90,000 KW (112,500 KVA) generator, manufactured by the Canadian General Electric Co. A Swedish firm supplied one 2,250 KVA generator and two smaller generators for each auxiliary turbine.

*Benmore Lake Data*

Area — 30.5 square miles
Maximum depth — 315 feet
Length of shoreline — 72 miles
Volume — 72,000 million cu. ft. (i.e. 1½ times Wellington harbour).

*Waitaki River*

The Waitaki River, on which the dam and lake stand, was originally called the Waitangi River. This is shown on a remarkably accurate map of South Canterbury, dated 1868.

*Fish Salvage*

On November 30th 1964, the biggest fish salvage operation ever undertaken in New Zealand commenced at Benmore. When the Waitaki River was closed to fill the new lake, it caused many small pools to be formed, leaving thousands of fish literally high and dry. The fish were uplifted and loaded on to tankers provided by the Ministry of Works and transported to the new lake. A large party of volunteers, local anglers and Acclimatisation Society Officers participated, and a grant of £2,000 was given to help with equipment costs, etc.

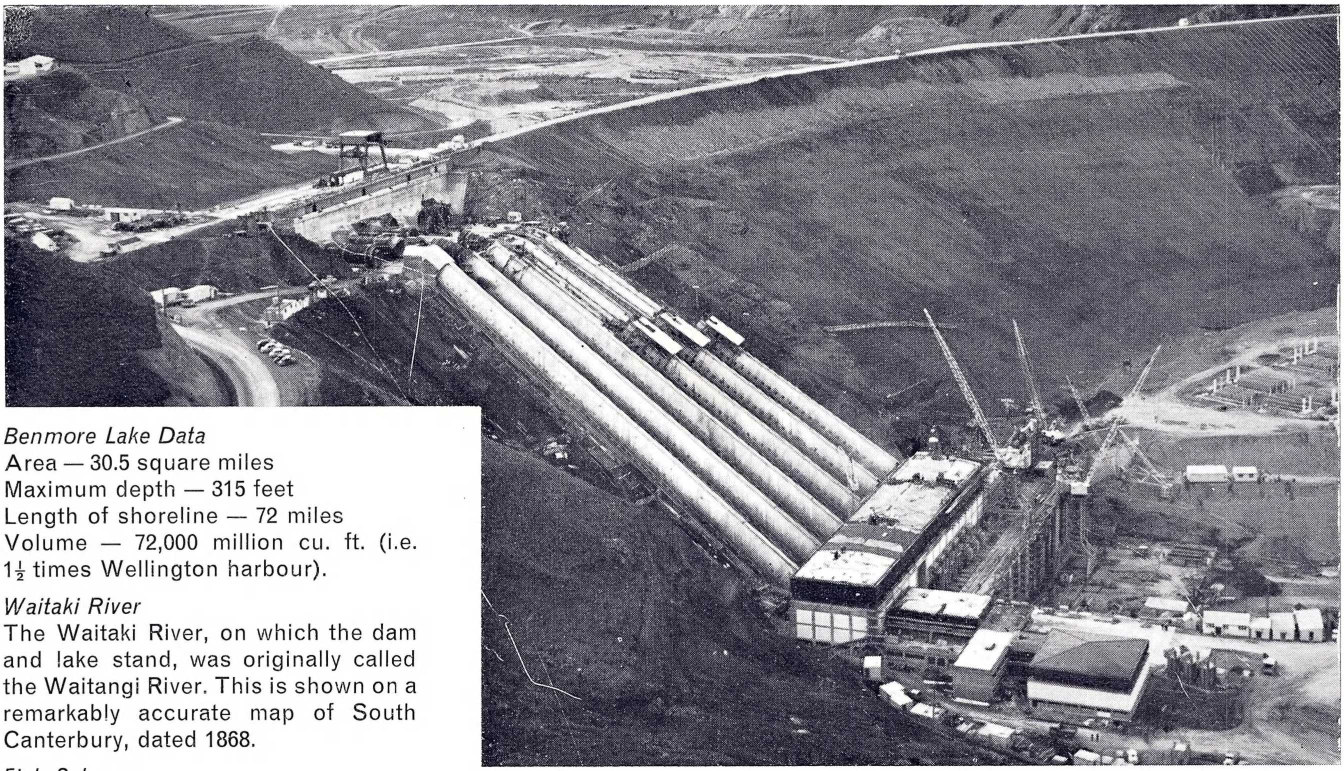
*Landscaping on a large scale*

The landscape treatment of Benmore was considered in four stages:

(1) Areas between village and dam, and areas by dam.
(2) Steep lake margins for stabilisation.
(3) Amenity planting around the lakeside.
(4) Future planting on peninsulas and islands where access at present is not available.

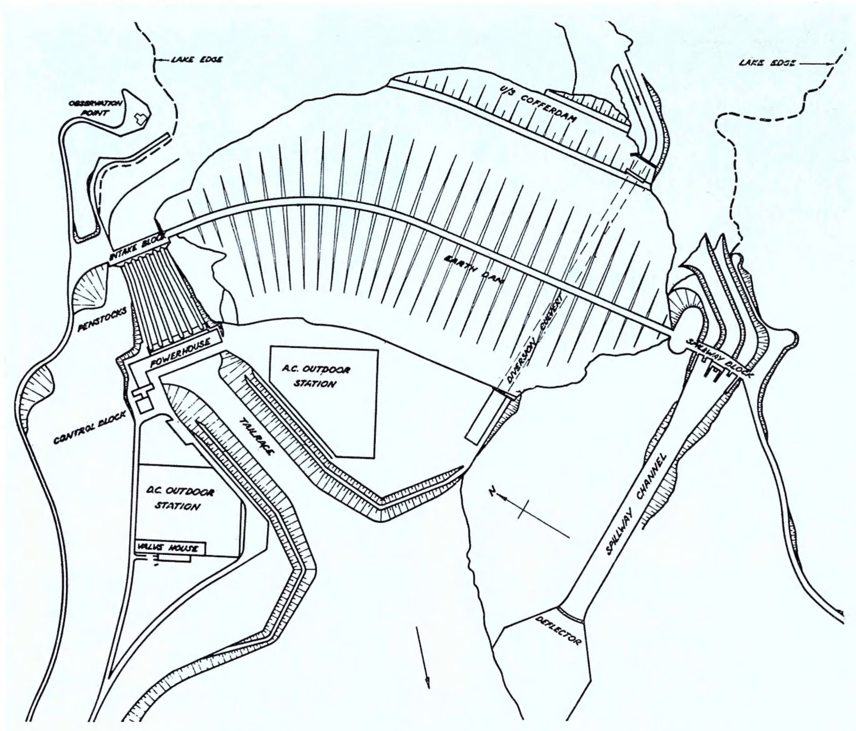
In 1963 some 38,500 trees were planted, and this was followed by a further planting of 40,300 in 1964.

A nursery area for the acclimatising and growing of stock on the site was made available by the Ministry of Works.



Benmore nears completion.

Map showing layout of area.



# SOME CONCRETE EVIDENCE

*Where did all the concrete come from?* The penstocks used a special high-strength concrete produced in a Winget Plant, but all the other concrete for construction, grouting and incidentals was made by the Johnson batching plant. Prior to its start at Benmore, where it turned out more than 600,000 tons of concrete, the Johnson batching plant was used at Roxburgh to produce all the concrete needed for the dam. Originally designed for and employed for the huge repair and construction task at Pearl Harbour, the plant was brought as a war surplus item from the United States after World War II.

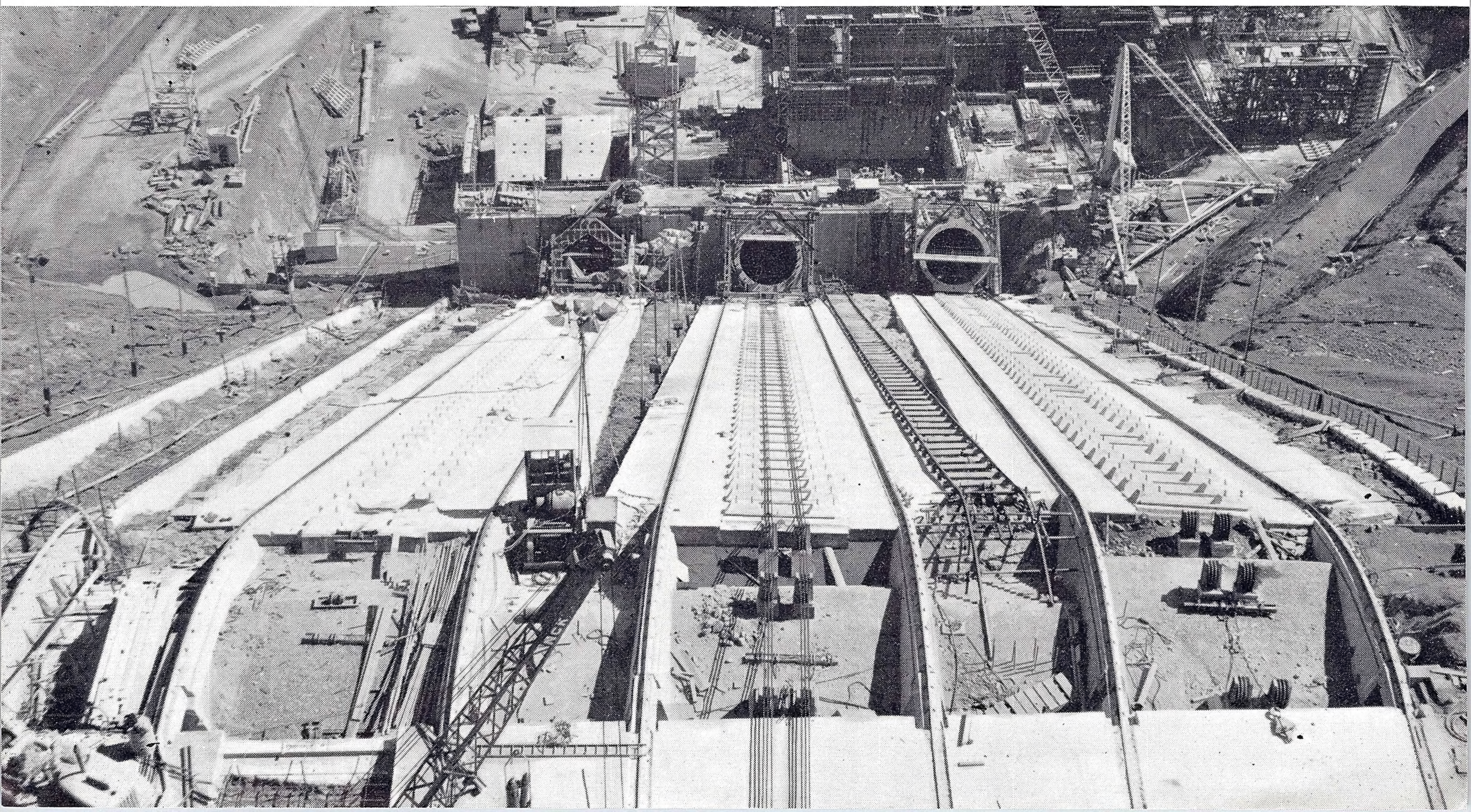
*Johnson batching plant.*

**The Penstocks.** This is a story that stands unique in the annals of construction history in this country. A special batching plant was required to produce the high-strength concrete required to resist the enormous water pressures to be expected.

The intake structure at the top of the penstocks consists of a number of massive blocks through which run six great mouth-pieces, each equipped with a $16\frac{1}{2}$ ton steel gate. It also carries a giant mobile service gantry. More than 20,000 tons of concrete went into the intake structure, and the supporting slopes for the penstocks consist of some 18,000 tons of concrete.

From each intake leads a 650 foot long penstock leading to the six turbine-generator sets. These penstocks have a $17\frac{1}{2}$ foot internal diameter and for 424 feet are constructed of pre-stressed concrete with the remainder consisting of reinforced concrete with a steel liner. The penstocks were constructed, with the aid of a special gantry to get them down the 35° slope, from 318 pre-cast sections, each weighing 58 tons and measuring 8 feet in length. Once in place, the sections were jointed with mortar.

*Early construction of the penstocks.*

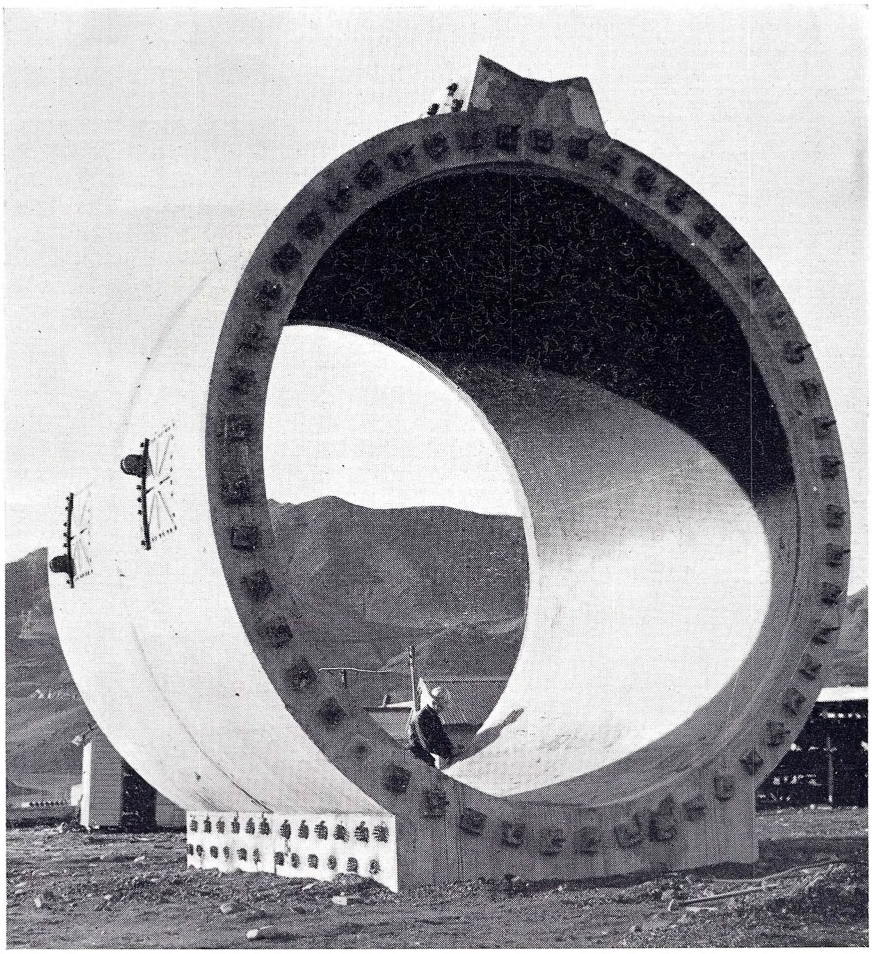


**The Spillway.** At the opposite end to the penstocks stands another concrete colossus... the spillway and sluice block.

The block structure has four spillway gates, each 35 by 38 feet, and weighing 67 tons apiece and two sluice gates, each 20 by 26 feet, and weighing 64 tons apiece. About 132,000 tons of concrete were consumed in the building of the spillway-sluice block... A massive structure indeed.

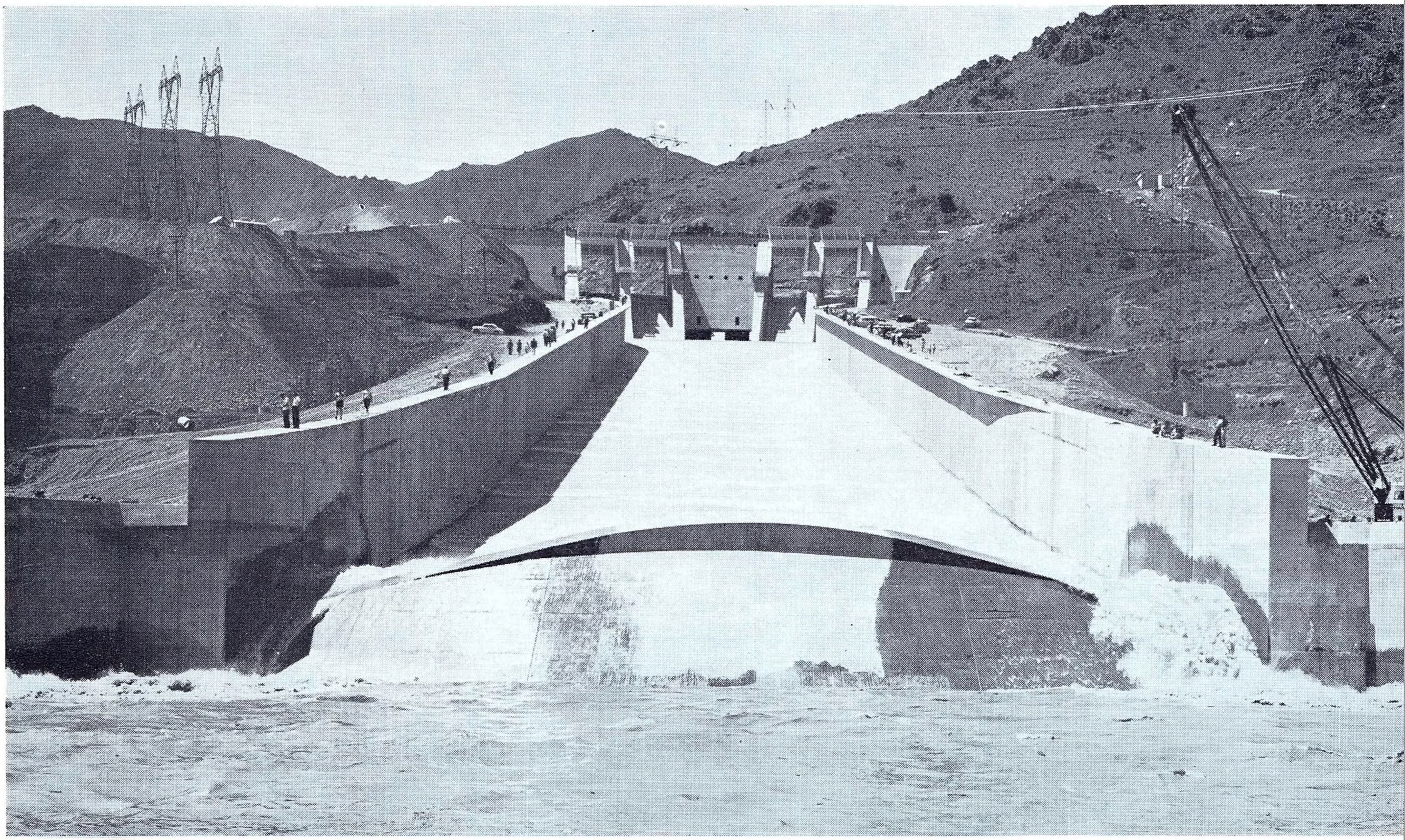
The spillway channel, in itself another engineering marvel, is nearly 1500 feet long, with 30 foot high walls. Initially 230 feet wide at the top, the channel tapers over a distance of 390 feet to a width of 120 feet which continues for a further 900 feet, flaring out to 146 feet at the bottom. Some 117,000 tons of concrete went into the construction of the channel — on an interesting gradient of 1 in 7.25.

The concrete deflector block, at the bottom of the channel, is 60 feet high (half of it is underground) and weighs 23,500 tons.



*Penstock sections awaiting assembly.*

*First water over spillway.*



# THE HEART OF THE PROJECT

The six generators at Benmore are each of 90,000 kilowats capacity and will all be installed by early 1966. Three of them, now in operation after passing the manual rotation and static tests satisfactorily, were first used in January 1965 to provide power for further testing of the DC transmission system. The generators have more than twice the capacity of the largest capacity previously in service in New Zealand, i.e. the eight 40,000 KW machines at Roxburgh. It would only take one of the Benmore generators to supply all the power for Dunedin city, even at peak hours.

Manufactured by Canadian General Electric, one of the companies in the General Electric organization, the final assembly and testing of the generators was done by New Zealand Engineers as they were too large to completely assemble and test in the factory. One of the major assembly jobs done in the Canadian Factory was that of meticulously stacking over 3,000 rim laminations (shaped steel plates). The accuracy requirements are such that each plate must weigh to within one-tenth of a pound, and the final assembled job must measure within thousandths of an inch. It is upon the care and quality of the workmanship involved that the life of the generators depend. Huge and powerful though they are, the dependability and long life expectations are such that a major overhaul should not be expected for over 25 years of service. Delicately balanced within minute tolerances, spinning at maximum loads at 166.7 rpm, seated on massive foundations and encased in hundreds of tons of protective concrete, they are designed, built and installed to last.

*Technical Specifications*

Manufacturers — Canadian General Electric.

6 only 112,500 KVA, 0.8PF, 166.7 rpm, 16,000V, 50 cycle generators.

Total weight — 482 tons.

Weight of stator within which the rotor revolves — 158 tons.

Weight of complete rotor and exciter — 241 tons.

Flywheel effect — $46.17 \times 10^6$ lb-ft.$^2$

Stator inside diameter — 25ft 7ins.

Stator core length — 6 ft 2ins.

Designed overspeed ratio — 1.68

Transient reactance — 26.4%.

Subtransient reactance:

Direct axis — 17.4%

Quadrature — 19%

Synchronous Reactance — 114%.

Stator temperature rise — 60 deg.C.

*The Transformers*

General Electric were also the suppliers of the two interconnecting transformer banks which link the respective halves of the 16KV bus to the 220KV bus. There is also a spare unit. They comprise of 7 single phase transformer units, outdoor type, oil-immersed, forced oil-water cooled.

*Technical Specifications*

Manufacturers — Canadian General Electric.

2 only 220 MVA 16/220KV. TCOL, plus a spare unit.

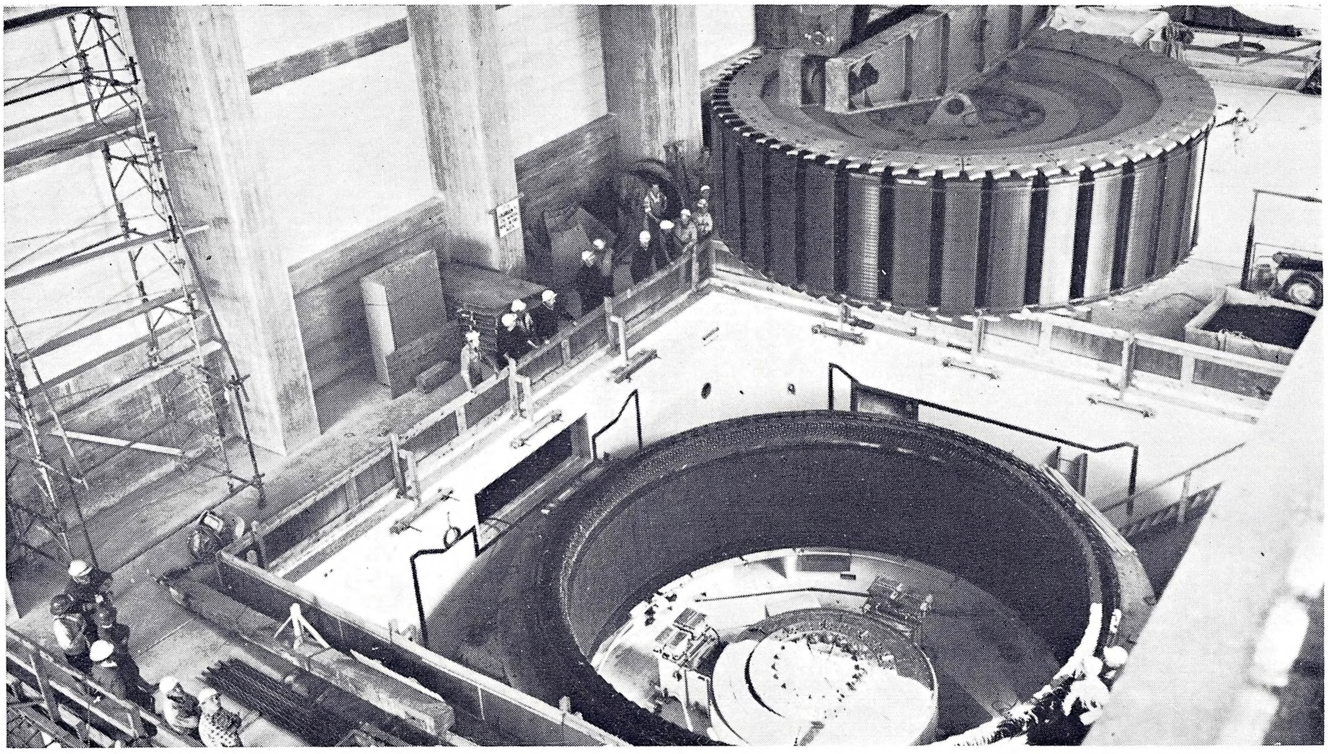
Tap changing on load,

Triple wound 16/9.05/127KV normal ratio.

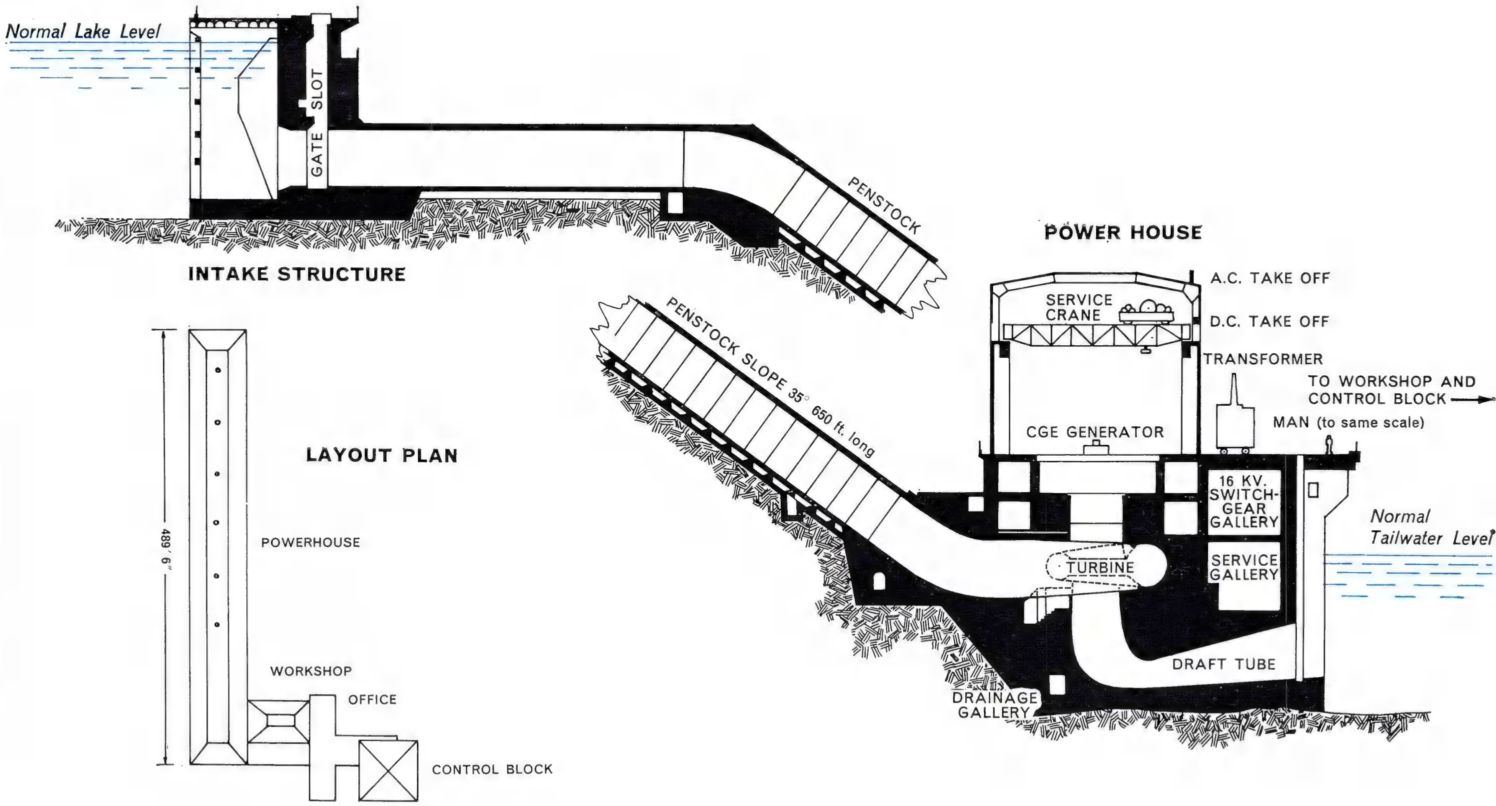
66.67/20/66.67 MVA Rating.

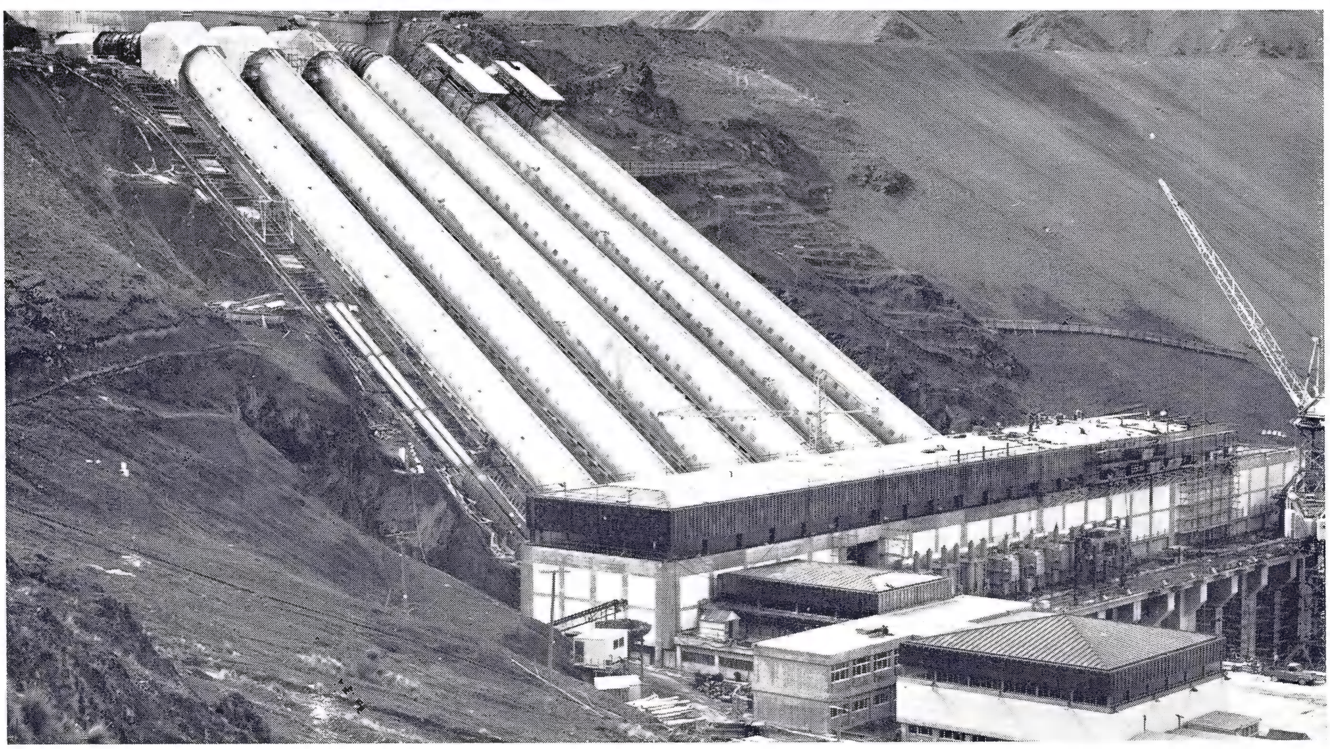
Transport Weight — 68.5 tons.

Service weight — 102 tons.



*Lowering rotor for No. 3 generator*



*Penstocks and powerhouse in final stage of construction.*

# BENMORE TO HAYWARDS 500KV TRANSMISSION LINE

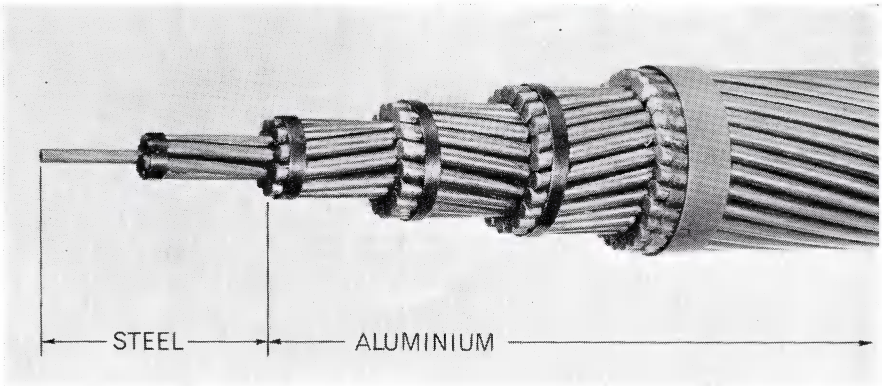
This is the first New Zealand example of long distance direct-current transmission and it is on a scale unequalled anywhere in the world with the possible exception of the Soviet Union. However, in a few years it will be exceeded in size by even larger schemes now being planned in the USA.

All large scale power generation is of alternating current, alternating back and forth at 50 cycles per second — which is stepped up through transformers from the generation voltage to high voltage for long-distance transmission; then it is stepped down through more transformers for local distribution. Direct current —smoothly flowing — is under certain conditions more economical in long-distance transmission, but direct current cannot be stepped up and down to meet requirements. So Benmore power, generated as AC, is converted there to DC, and so brought north, and at Haywards is reconverted to AC and fed into the North Island System.

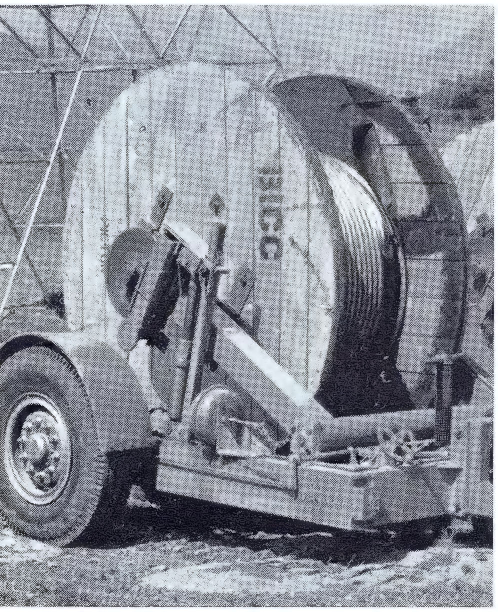
In general, the greater the transmission distance, the higher the main line voltage. New Zealand's main transmission lines operate at 220,000 volts, but because of the 354 miles between Benmore and Haywards a direct current, super-high voltage of 500,000 volts is employed. From the economy point of view, notwithstanding the cost of conversion equipment, the savings attained by the DC transmission are very great. Over the transmission system as a whole, i.e. land lines and sea-cables, there is a saving of almost £8 million through the operation of direct-current transmission.

In 1963 the New Zealand Electricity Department started their huge task of erecting the 354 miles of direct-current transmission line between the Benmore Hydro Station and the Haywards Sub Station. Altogether some 300 men were employed on the route in the South Island, and well over 50 men were concerned with the small stretch from Oteranga Bay to Haywards, in the North Island.

Whilst the 500,000 volt system is feeding direct current to the North Island, a 220,000 volt system is also feeding alternating current into the South Island grid. The steel for the transmission towers was supplied from Italy, with 1,646 towers being involved in the North Island DC line and over




*Section of conductor.*




*Conductor drum.*

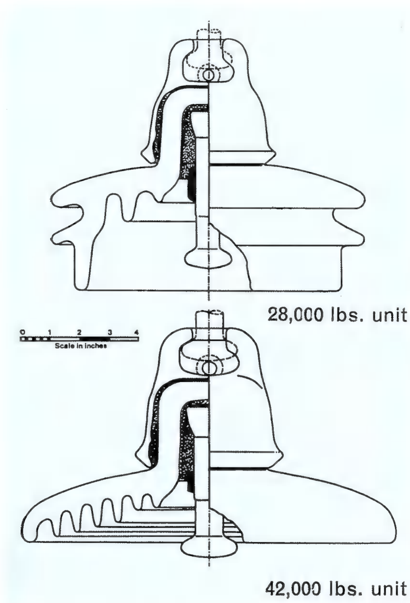
*Rigging the conductors.*

700 towers for the AC line to the Islington Sub Station (8 miles from Christchurch). Each of the towers is constructed from approximately 6 tons of steel, and supports a combined weight of nearly 17 tons of conductors every mile. Total weight of steel in all the towers in the Benmore-Haywards line is 8,000 tons.

The conductors, i.e. the transmission lines, are strung in pairs, and although 1½″ thick, weigh under 2 lbs. per foot. All told, some 1,416 miles of conductors were strung. The conductors, manufactured by British Insulated Callender's Cables Limited, Great Britain, are aluminium and steel reinforced. The four conductors will transmit 600MW at a pressure of 500KV and are constructed of seven strands of .1138″ diameter galvanised, high-tensile steel over which are laid 76 strands of .1463″ diameter aluminium. In terms of household power, they will carry a load of 600,000 units per hour — greater than the whole South Island consumption.

The Insulators used to support the conductors were manufactured by NGK Insulators Ltd. Japan. Over 57,000 of them were used, and they were strung up mainly in sets of 12 or 13. The breaking strains of the insulators ranges from 15,000 lbs. to 42,000 lbs, which means they can take up to approximately 10 tons in weight.

In the 15% of line classified as "Coastal", insulator strings of 13 to 15 feet long are being used (i.e. about double the length of those used elsewhere on the line) as protection against salt spray contamination. Considerable attention has been given in the design of the insulators with regard to the possible effects of the salt spray pollution. It is also intended to install equipment to monitor leakage currents on certain insulators.




*NGK Insulator Units.*

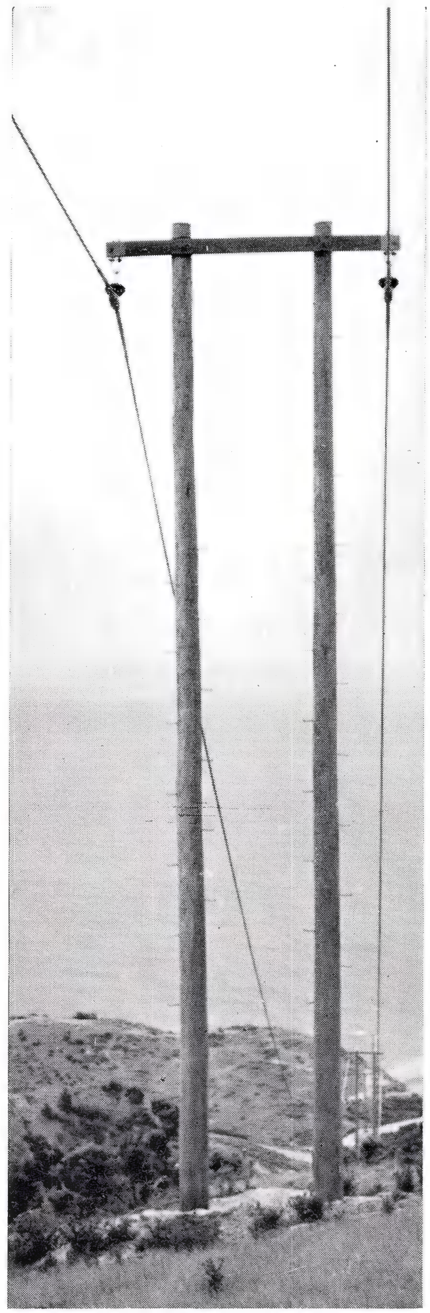
Much time and attention was also given to the stress and strain involved in both the conductors and towers, as in certain parts winds of up to 154 mph have been recorded, and up to ¾″ of ice can be expected to settle on the conductors in the high altitude parts.

There are two converter stations, one at Benmore and one at Haywards. At each station mercury arc valves are contained in a valve house which also includes the control rooms and workshops for maintenance and degassing. The valve houses, approximately 400 x 100 feet in size are fully air-conditioned to decontaminate the air from mercury vapour, dust, etc. In the outdoor areas equipment is provided to suppress high-frequency oscillation in the various circuits and to protect the equipment from surges caused by lightning strikes and valve faults.

A galvanised steel earth-wire provides protection throughout the South Island line and also on 9 miles of the North Island line; between Oteranga Bay and the electrode tee-off point. Beyond the tee-off point, protection is provided by an electrode line, insulated to a BIL of 125KV, which is carried on a subsidiary crossarm 22 feet above the main conductors. The electrode line from the Haywards to the North Island sea-electrode station at Makara, is carried by steel towers for the first 2½ miles from the tee-off, and then by wooden poles on the remaining quarter of a mile to avoid corrosion trouble on the tower footing during operation of the electrode.

A power-line carrier system provides communications between Benmore, Fighting Bay and Haywards at all times.

*Cost:* A final cost has not yet been produced, but it is expected that the final cost for the transmission line will be in the vicinity of £4,876,000 made up of the following expenses . . . cost of towers, conductors and insulators, erection of the towers and conductors, camp accommodation, roads and bridges, machinery hire charges, and miscellaneous extras, e.g. supervision costs.

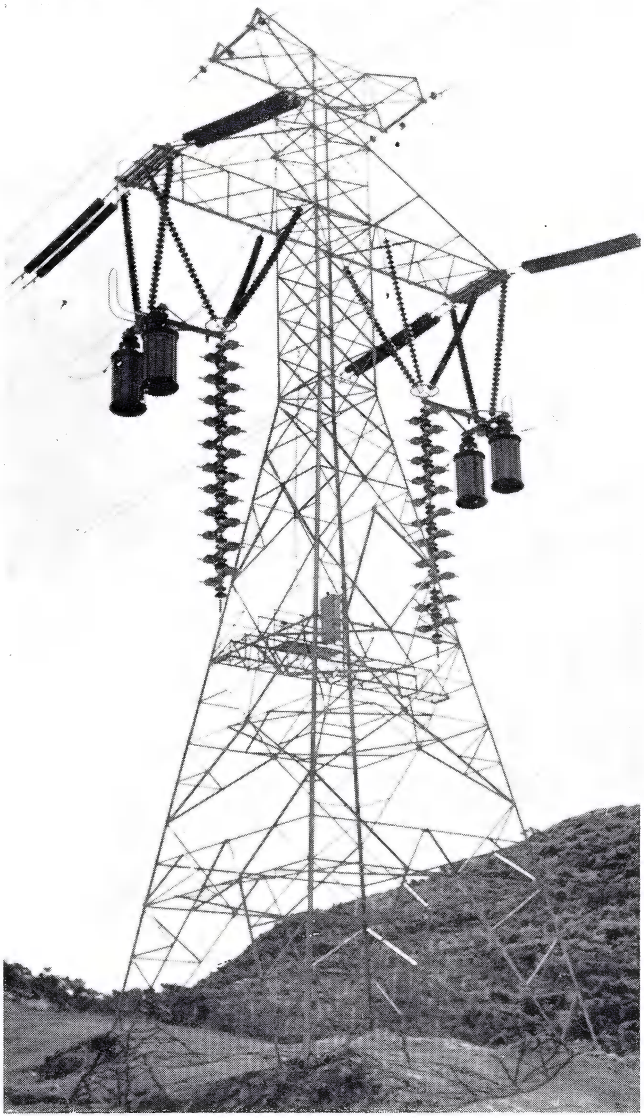


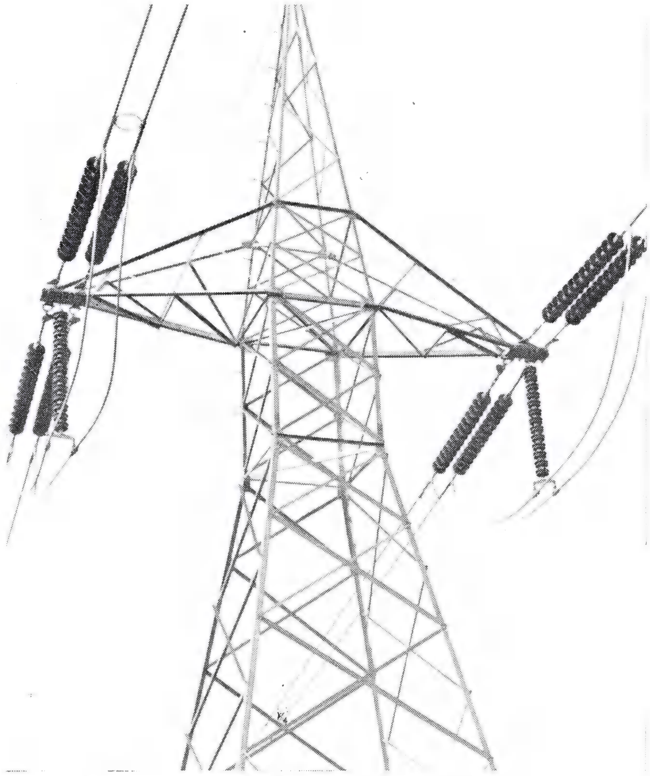
*Wooden poles used for coastal areas.*

*Bridges:* For certain back-country inaccessible parts, roads and bridges had to be built for the transporting of the tower steel, etc., and future maintenance access. Altogether there were 10 concrete and 4 wooden bridges built, and nearly 275 miles of new roads had to be constructed, 140 miles of which are only suitable for use by four-wheel drive vehicles.

*Fitting spacers near Wellington.*

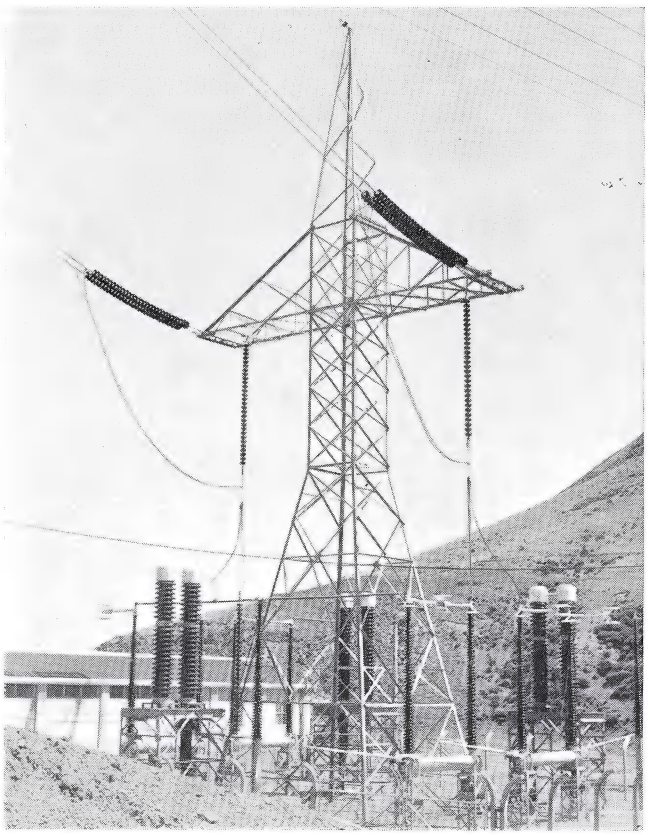
*A strain tower showing the numerous types of insulators used.*





*Terminal tower at Oteranga Bay.*

*A light strain tower at Jollies Pass.*

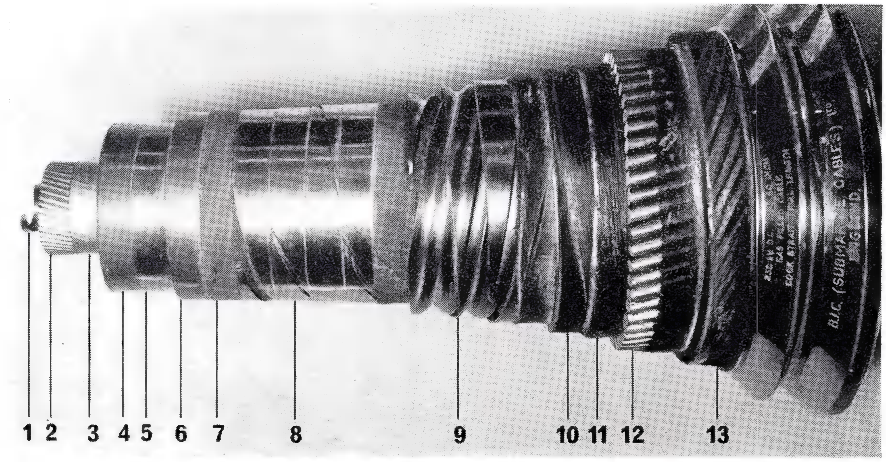


# COOK STRAIT CABLES

In March, 1956 the firm of British Insulated Callender's Cables Ltd., (BICC), suppliers of the transmission line conductors, were instructed to investigate the practicability of linking the power resources of the North and South Islands by underwater cables. This investigation resulted in a trial length of cable being laid to provide data to enable a final decision to be made. The trial cable, laid from Oteranga Bay, was half a mile long and five inches in diameter, and consisted of a single core, high pressure gas-filled type rated at 250,000 volts DC with a hollow copper conductor, pre-impregnated paper insulated and lead sheathed. The cable, weighing about 35 tons all told, remained on the sea bed for two years, and then was recovered and given further tests on land.

In 1961 the BICC Company was awarded the contract to manufacture and install 76½ statute miles of submarine gas-filled cable, together with all terminations, accessories and spares necessary. It was decided also to use three single-core cables, two of which would form the conductors of the direct current circuit, and the other to be a spare.

Due to the width of the crossing, the depth of the sea bed and the turbulence of the weather and sea conditions, the external protection of the cables had to be specially designed. Basically the submarine cable consists of a 0.80 sq.in. conductor comprising four layers of annealed copper wires laid over a spiral steel gas duct. Paper tapes impregnated with a compound of mineral jelly are applied over the conductor to form the insulation. The insulation is pressurized with nitrogen gas via the duct at 425 lb. sq. in. and contained with a lead-alloy sheath, reinforced with steel tapes. The reinforced cable is then protected against corrosion by a vulcanised rubber sheath, armoured with heavily galvanised steel wires and finally jute served over-all. Its weight in air is

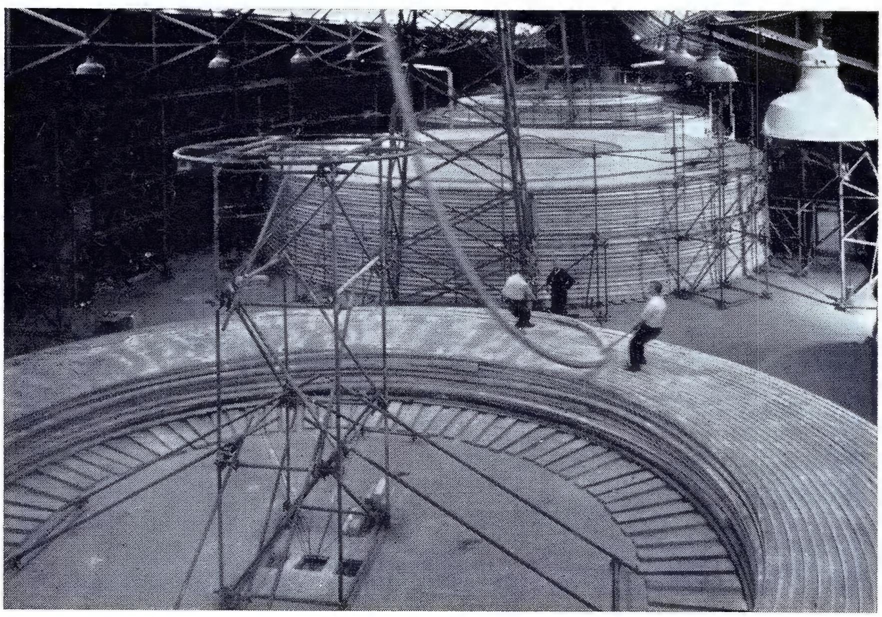



1 Steel spiral duct
2 Stranded copper conductor
3 Conductor screen
4 Paper dielectric
5 Dielectric screen
6 Lead alloy sheath
7 Bedding tape
8 Reinforcing tapes
9 Bend limiting lock armour
10 Anti-corrosion serving
11 Bedding for armour
12 Galvanised steel wire armour
13 Jute serving

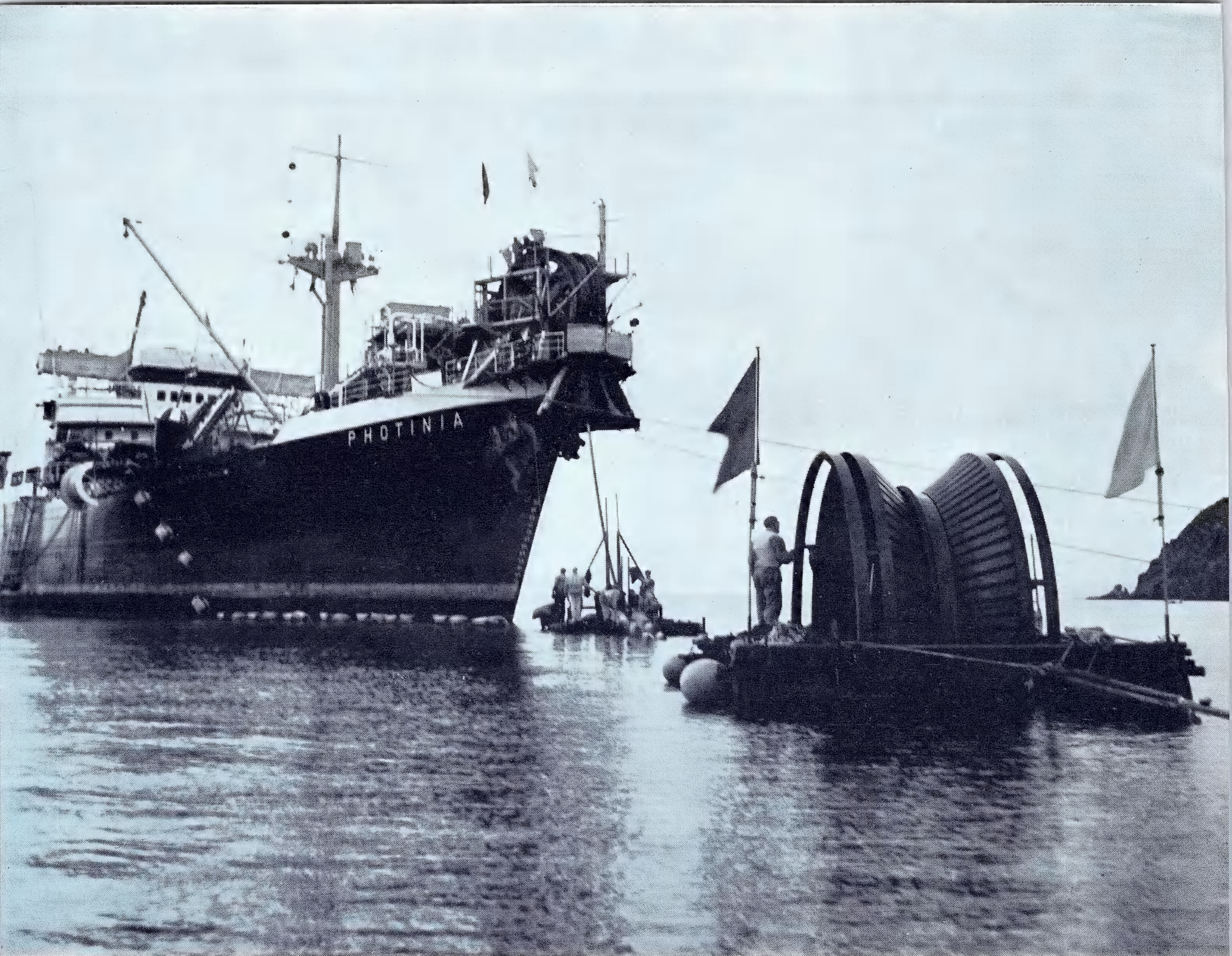
*A section of Cook Strait cable.*

88lb. per sq. yd. and 63lb. per yard in water; and the operating pressure for the gas is 50lb. per sq.in. higher than the external water pressure at the deepest parts of the cable route — which is approximately 140 fathoms. The maximum gradient involved is 1 in 5 and each cable weighs 1,500 tons. At the shoreline the cables are jointed to 1.25 sq.in. land cables and then terminated in 27 feet high sealing end structures each of which include a second porcelain bushing especially for the nitrogen-gas connections. The sealing end porcelains are protected from salt spray accummulation and pollution by means of water-spray equipment.

At each terminal station there is also an airbreak switch to permit any two of the three cables to be connected to the two overhead line conductors. All insulators used in and around the terminal stations have a leakage distance of 500 inches, and clearances based on 1050KV BIL. 32½" rod gaps protect the cables from surge voltages. Gas cylinders and control equipment housed nearby automatically maintain pressure to give a safe margin over the external pressure. Thus, in the event of a minor puncture, gas pressure would prevent water from entering the cable until repairs can be arranged. In the case of major damage, the ingress of water would be halted at the nearest of the gas traps created in the cable by the uneveness of the ocean bed.



*Spare cable being transferred to the 'Photinia'. In the background can be seen the three main cables*




*At the bows of the 'Photinia' can be seen the float rigger and at the right of the picture can be seen the floating head—both are involved in the process of bringing the cable ashore.*

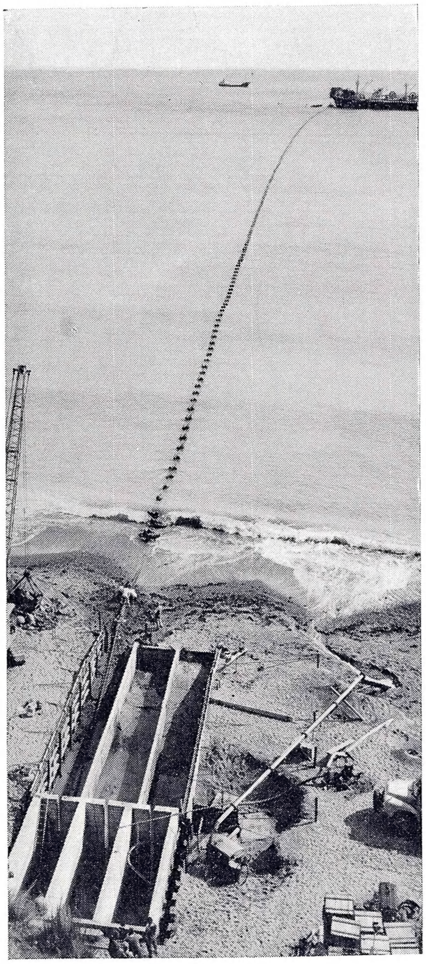
# LAYING THE CABLE

Due to the size and weight of the cables, and there being no existing cable-laying ship capable of handling them, it was decided to convert the MV "Photinia" (10,000 tons dead weight) for the purpose. She was previously used for carrying bulk cargoes, so therefore was ideally suited to carry the 5000 tons of cable necessary plus all the equipment needed. The No. 1. hold was equipped as an engine room, with a large diesel engine to drive the Voith Schneider propellor (installed in the bows) also being installed there. No. 2. hold was used to store all the engineering equipment, and holds 3, 4, and 5 were used to carry the coils of cables and steelwork structures to support them.

The aft hold No. 6 was converted to living accommodation for the 40 cable hands and other specialised workers. Above deck was the massive and complicated equipment necessary for the handling and laying of the cables.

Trial runs were then held, using practice cable, in Scottish waters, and in Cook Strait itself. After the trial runs had been completed, laying times then depended on favourable climatic conditions.

When the cable-laying proper began, with the laying of the shore end of the cable at Oteranga Bay in the North Island, launches brought by the tender ship "Arran Firth" took station in-shore of the southern and northern mooring buoys. "Photinia" then entered the bay and, as she approached the moorings, the launches picked up $6\frac{1}{2}''$ ropes with snap-on hooks and attached them to the buoys. The ship was then moored fast with her stern to the shore. With the "Photinia" correctly positioned, one launch then placed the float rigger in position and the other launch brought a pulling bond for attachment to the cable at the bow-sheave. As the cable was then pulled out to the beach by a 10 ton winch, twin floats were joined to it. When the correct amount of cable had been pulled ashore the float rigger was taken away and the twin floats deflated. As the cable sank additional cable was paid out from the ship to ensure the correct tension.



*Drawing the cable ashore.*

The "Photinia" now slipped her moorings and proceeded into Cook Strait. To ensure precise accuracy in laying the cable, so that its final position is precisely known, Decca Hi-Fix, a special navigation instrument, was used. For steering the ship on the selected route, the chart on the automatic plotter had the cable route drawn on it, and all the helmsman had to do was keep the stylus on the line. Conventional navigation was continuously maintained as well.

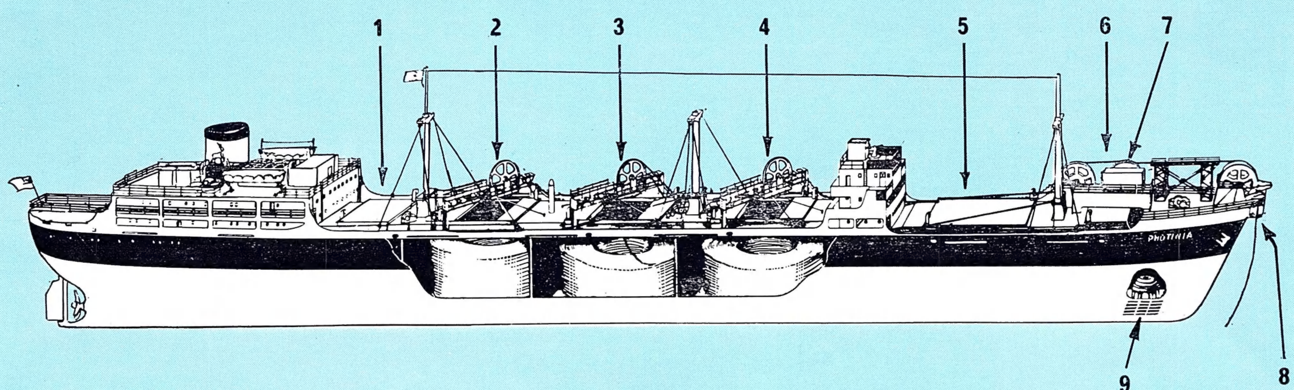
The landing of the Oteranga Bay cable end took nearly six hours, the trip across Cook Strait took six hours, and the landing of the Fighting Bay end another six hours — a long and hard-working eighteen hours per cable for the men involved.

The mooring procedure at the finishing end, Fighting Bay in the South Island, was similar to that at Oteranga Bay, but not stern on. A "Floating Head" was positioned at the bow, between the ship and shore, so that when the floating head was winched to the shore a bight of cable was taken with it. The cable was then cut on the ship, sealed and pulled up to the beach. As soon as the cable-end had been landed, work commenced on joining it to the land cable which was already installed.

The whole operation then had to be repeated for each of the other two cables, the distance between cables being 1,000 yards except where they converged at the terminal points.

Upon completion of the laying of the cables, both gas and electrical tests took place. The gas tests involved pressure of 600lbs. per sq.inch for the period of four days, whilst the cables were electrically tested at 520,000 volts for 30 minutes.

However, in spite of the most careful seamanship and overall control exercised, the hazardous and well-known Cook Strait conditions were such at one point that the "Photinia" was caught in a powerful and very sudden current which moved the ship causing a severe twist in the third cable, damaging the insulation. When the fault was discovered, the cable was explosively cut and the shorter length uplifted from the sea-bed and brought ashore. The larger length was sealed and relaid while the faulty section was cut out of the shorter length and replaced with sound cable. The final process involved the making of a joint at sea and the relaying of the cable. The spare cable was then also tested and ready for future service.




## M.V. PHOTINIA

**1** No. 6 Hold Temporary accommodation
**2** No. 5 Hold 25.5 m. length of cable
**3** No. 4 Hold 25.5 m. length of cable
**4** No. 3 Hold 25.5 m. length of cable 5 m. of spare cable
**5** No. 2 Hold Stores
**6** No. 1 Hold Voith Schneider motor Diesel generating set
**7** Cable engine
**8** Cable bellmouth
**9** Voith Schneider propeller

# INAUGURATION CEREMONY AT BENMORE

## 15 MAY 1965

On this date the Prime Minister, Rt. Hon. Keith Holyoake, pushed a switch at 2.45 p.m. to start an auxiliary generator which, in turn, started the main generators to send power through the inter-island link. The Benmore-Cook Strait scheme was then officially in operation.

During the morning, guests and visitors were shown over the project, and at 1.45 p.m. the official opening speeches were started.

The Hon. T. P. Shand as Minister of Electricity was host, and the official guest list included Sir William McFadzean (Chairman of the BICC Group) representing British and Commonwealth contractors, Prince Bertil of Sweden, Diplomatic representatives of the countries supplying major components, representatives of New Zealand and other overseas contracting firms, local residents and people directly interested, and senior officers of the New Zealand Electricity Department, Ministry of Works and other Government departments concerned.


*The opening speech being presented by the Prime Minister, Rt. Hon. Keith Holyoake. Seated on his left can be seen Sir William and Lady McFadzean.*

# SIR WILLIAM McFADZEAN AND BICC

For the company of British Insulated Callender's Cables Limited, the largest electric cablemaking group in the world, (they spend £3 million a year in research alone), the Cook Strait Cable project was a highlight in their long and world-famous history of cable-making and laying.

To quote Sir William McFadzean in his annual report to shareholders, "We were well aware of the challenge we had accepted, for these three 250,000 volt D.C. cables are 25 miles long without a joint, weigh some 1,500 tons each, and are up to five inches in diameter; and Cook Strait is one of the most difficult waters in the world".

*Relaxing after the ceremony, (from left) Hon. T. P. Shand, Prince Bertil, the Prime Minister and Sir William McFadzean.*

Therefore, to make sure that everything would be perfect they went to unlimited expense and trouble, including not only the conversion of the 10,000 tons freighter "Photinia" for the intricate cable-laying work, but also the construction of a special factory in Manchester to manufacture these phenomenal cables.

Sir William McFadzean, Chairman of the BICC Group, was, as mentioned before, recently out here in New Zealand to represent his company at the inauguration ceremony at Benmore.

Sir William, who was accompanied by his wife, Lady McFadzean, is also Chairman of the British National Export Council and the Commonwealth Export Council, and represented them at the inauguration ceremony.

*SIR WILLIAM McFADZEAN, CA, Comp. IEE*

*Sir William McFadzean made his first contact with the electrical industry in 1927, when, after becoming a Chartered Accountant, he served on the audit side of B.I. Cables for five years. Progressing from Accountant to other senior positions, he became Chief Executive in 1945. One of his major tasks in this position was the merger of the British Insulated and Callender's Cable companies. With his wide knowledge of export matters he has served on many advisory boards and also has been President of the Federation of British Industries, and the Export Council for Europe. A knighthood was conferred upon him in the 1960 Birthday Honours.*

# NEECO IS THERE—FROM BENMORE TO HAYWARDS

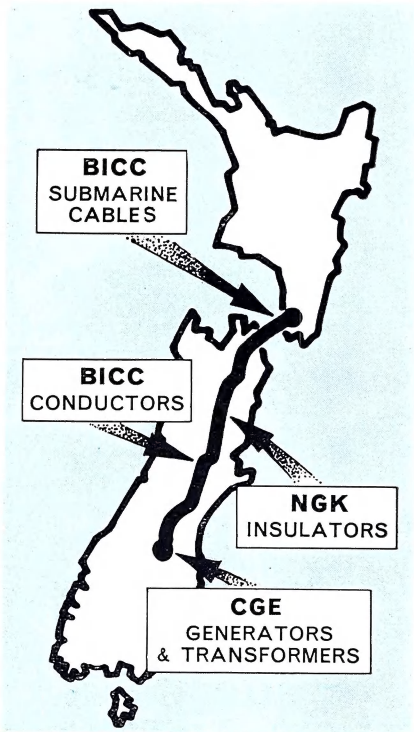
We ourselves are well-connected with the Benmore scheme, as suppliers of electrical materials and appliances for both the construction site and the township, e.g. heaters, ranges, floodlights, Tirfor hoists, wiring, and safety belts . . . we are also very proud to be representatives for three of the major overseas Companies involved: BICC (Conductors and Cook Strait cables), CGE (Transformers and Generators), and NGK (Insulators.)

**BICC** British Insulated Callender's Cables Limited, suppliers of the ACSR Conductor used on the Benmore-Haywards Line, and of the submarine cables linking the two islands, are one of the great cable manufacturers.
From modest beginnings in the manufacture of rubber insulated wires and cables, they have progressed to a point where they now manufacture all types of electrical conductors from the ultra-fine wires used in modern electronic and space-age equipment to the heaviest super-tension cables required for the bulk transmission of power. Every process from the refining of the copper billets to the packing of the finished product is carried out in their plants and in their research laboratories; they are continuously developing new materials and new processes to meet the challenges presented by the demand for higher voltages, heavier currents and longer transmission distances.

**CGE** Canadian General Electric Co, one of the companies which goes to make up the huge General Electric combine, is already well-known in this country as suppliers of generators and transformers for New Zealand's rapidly growing generating complex and their continued success is, in part, due to the fact that they are situated in a country themselves with a rapidly growing electrical load and a vast potential of hydro-electric generation waiting to be tapped.
Apart from major items of generating equipment, they manufacture power switchgear, a full range of motors from the largest to the smallest, control gear, lighting equipment, domestic appliances, radio and television equipment, lightning arrestors, meters, etc. In conjunction with the Atomic Energy Authorities in Canada, they have been in the forefront in developments in this field and their Civilian Atomic Products Department has for some years been engaged in the manufacture of the very specialised equipment required for this new method of generation.

**NGK** NGK Insulators Ltd. is a Company which has risen to prominence in the electrical industry by concentrating on one product and one product only — the manufacture of electrical insulators of all kinds with their associated ironwork.
From the finest raw materials, all available in Japan, and with the most modern processes, they have developed a range of insulators which are unsurpassed anywhere.

Many thousands of NGK EHT Line Insulators have been imported into New Zealand over the past years and have been used by NZED and Power Supply Authorities. NGK bushings are used in the transformers and switchgear produced by many of the prominent electrical manufacturers. While the vast majority of porcelains which they produce are standard lines, NGK will design and develop a special type if necessary; some of the insulators used in the Benmore-Haywards line were, in fact, specially designed for this all-important project.




# COLERIDGE OPENING FIFTY YEARS AGO

On November 28th, 1964 a function was held at the Coleridge Hydro-Electric Power Station, Canterbury, to celebrate and mark the fiftieth anniversary of its commissioning. The first of the large hydro-electric generating schemes to be undertaken by the State, it was begun in 1911 and went into operation at the end of 1914. By March, 1915 the city of Christchurch was, due to further expansion, able to receive a regular power supply.
The opening, held on Wednesday November 28th, 1914, was an important event, with well over 100 people travelling the 63 miles from Christchurch to attend, even though it was pouring with rain. Mr W. E. Massey, the Prime Minister of New Zealand at that time, had the honour of turning on the water, starting a generator set, closing the switch, and declaring it "open". The Government electrical supply was now launched.
The original Coleridge generators were of 1,500KW each, three being installed first, and then a further six later. Originally a 4500KW station, the present capacity of Coleridge is now 34,500KW.
Our connection with the State power stations started with this scheme, when, as representatives, at that time, of British Thompson-Houston Co. Ltd, we supplied two of the generators, and on behalf of one of our present agencies, General Electric Co. USA, we supplied three of the five transformer banks.

# ONE HUNDRED YEARS AGO

A century ago, on April 9th, 1865 to be exact, a boy by the name of Carl August Rudolph Steinmetz was born in Breslau, Germany. His childhood years were ones of happiness, slowness in school, a home laboratory and eventually entrance to the University of Breslau in 1882. Fleeing shortly afterwards from Germany because of Socialist charges, he entered the Zurich Polytechnic in Switzerland. A year later he and a new friend left for America, where he obtained work and Americanized his name to Charles Proteus Steinmetz.

It was not long before the engineering profession began to hear of this young man. At the age of 26, he announced a discovery in the field of magnetism which established his reputation. Prior to this time, designers of electric machines knew that iron in the magnetic circuit of alternating current machines became hot when the machines were operated. This, of course, was a loss of useful energy, but no way could be found of calculating the amount of the loss. Steinmetz demonstrated and explained in a law how this information could be obtained. Acclaimed immediately as outstanding, it became known as "The Law of Hysteresis Loss" and is today used in designing all electric machines, from sewing machine motors to hydroelectric generators.

The Company he was working for passed out of existance in 1892, and in 1893 he was asked to join the General Electric Company. This he did, and a year later he was shifted to the Company's headquarters.

He became quickly recognised as one of the greatest engineers in a field of comparative mystery at that time — alternating current work. In just a few years after the publication of his article on hysteresis loss he soared to his full height, working out entirely new methods for solving electrical problems. The impact of his mathematical work can be fully appreciated when one realises the fact that today the principles laid down by him are taught in all engineering schools, and are used in practically every application in the field of alternating current. Generation, transmission, and the utilization of electric power are largely possible because Steinmetz showed how predictions could be made as to the operation of alternating current devices. Previous to this time, electrical engineers were faced with an almost insurmountable wall, for while the great possibilities in the field of alternating applications were suspected, inventions could not be made because the engineers did not understand the behaviour of alternating current.

Then Steinmetz presented the first of his mathematical contributions before the International Electric Congress. His method at first was not even appreciated, let alone understood, so, realising that more explanation would be necessary, he began writing textbooks. Four years later his first work was published under the title "Theory and Calculations of Alternating Current Phenomena". In subsequent editions, this work was expanded into three editions, indicating the vast scope of this field — "Alternating Current Phenomena", "Electric Circuits", and "Electrical Apparatus".

Here was a complete unveiling of the mystery. The methods he expounded were new mathematical tools which were badly needed. Later, he carried on and wrote two textbooks entitled "Theoretical Elements of Electrical Engineering" and "Engineering Mathematics".

Many were the honours showered upon him, including election as President of the American Institute of Electrical Engineers, and having the degree of Doctor of Philosophy conferred upon him.

As an inventor, that is, as an actual designer of new apparatus and mechanisms, Steinmetz was less well-known. However, one of his earlier developments had a very wide application — it was the magnetite arc lamp, which was used for many years as a brilliant and highly efficient street lighting. From investigations carried out at home, with a machine he produced to create artificial lightning, he soon became nicknamed "The Thunderer". His experiments had a practical result, in that he invented apparatus which has helped to protect electric systems from the effects of lightning.

Returning from an evening public address in 1923, he left almost immediately in a hectic rush for a Convention of the American Institute of Electrical Engineers. The return journey was devoted to sightseeing and Steinmetz enjoyed the trip thoroughly, but it had seriously sapped his strength, and his doctor ordered him to bed. Two weeks later he was still not well, but rallied sufficiently to get dressed and leave his bed. The next morning his adopted son Hayden persuaded him to stay in bed until he had eaten his breakfast. But a few minutes later when Hayden's son took his breakfast up to him, Steinmetz had passed quietly away.

Only two things remained to be said about this great man. One is that everyone, from neighbours to people like Einstein, Edison and Marconi, all had a tremendous love, respect and admiration for him — a thing which speaks for itself. Secondly, the fact that wherever we find electricity reducing the cost of manufacturing products so that all can afford them, and wherever we find it lessening the burden of workmen in factories and housewives in homes, there we find a part of the fruit of Steinmetz' genius. We may therefore say that the story of Steinmetz and electricity, especially in the field of alternating current, are synonymous, and that the story of Steinmetz is also a significant portion of a thing which grew from a scientific curiosity to a powerful and beneficial factor in our lives as they are today — ELECTRICITY.